Malting, Brewing Metrics, Grain Bill Calculations

Malting

1) Harvest - Barley moisture @ ~15%
2) Store - Barley dried to ~11% moisture, then stored
3) Steep - germination initiated moisture from 11% → 15% goes to ~50%
   * Steeping occurs for 2 days
4) Modification - Barley grows → **Green Malt**
   * Temp held @ 16-20 °C
   * Embryo Growth → G.A. dispersed along aleurone layer
   * Endosperm layer breaks down
   * Acrospire and rootlets grow
   * When Acrospire reaches 75-100% of barley length = fully modified
   ** interplay btw. endosperm expenditure and endosperm unlocking
5) Kilning → moisture dropped to ~4-5%
   * Rootlets tumbled off

G.A.
* Added to Step 4 → [0.2 - 0.25 PPM]
* Comes from fungi:
  Gibberella Fuji Kuroi

Malt Characteristics

Base ⟷ Specialty

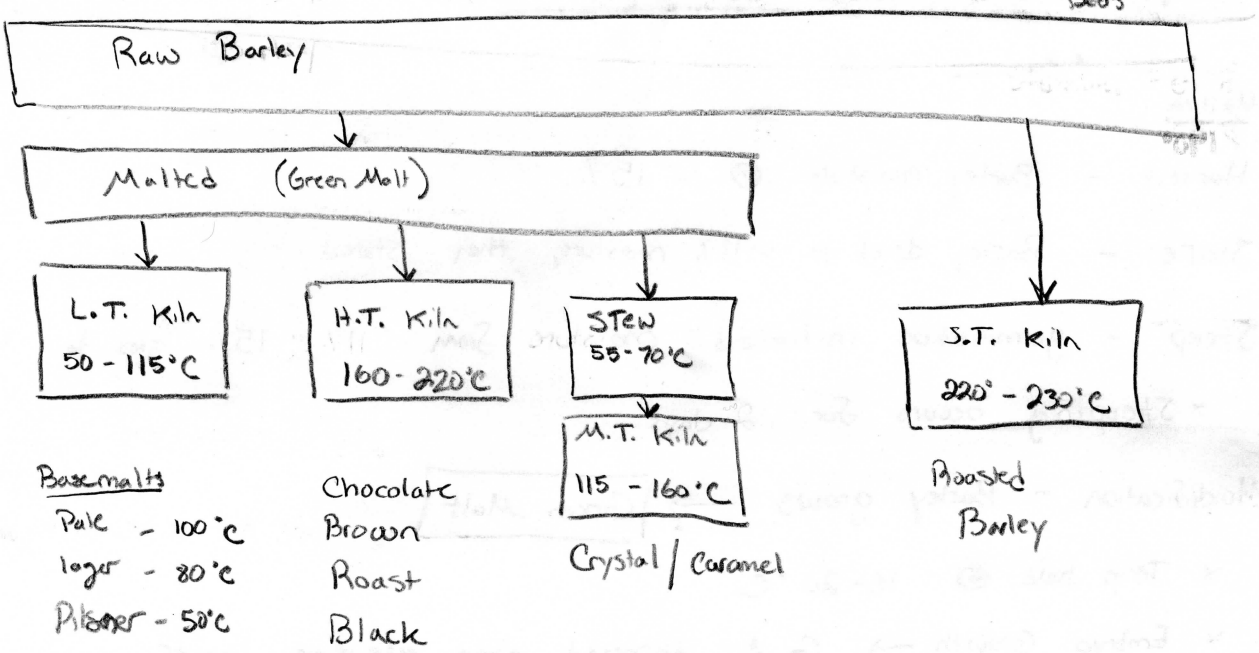
↓

Depends on moisture, heat, & kilning process

Malting Summary

1) Harvested Barley Steeped in Water → Germination
2) Barley grows → Modification
3) Fully modified → Green Malt

* Designing Great Beers



L = Low
M = med
H = High
S = Super

Flavor Reactions

- 2 types

Caramelization
Maillard Reactions] - non-enzymatic browning reactions

Caramelization - Caramel, Burnt Sugar, Honey, Toffee

110 - 160° C
< 3% moisture
Absence of O_2 →

Pyrolysis

- Heat to break down sugar bonds
- Repolymerize to form caramelization products

Sugars

- Caramelan - $C_{12}H_{12}O_9$
- Caramelen - $C_{36}H_{12}O_9$
- Caramelin - $C_{24}H_{26}O_{13}$
- Aromas
  - Furans - Nutty
  - Diacetyl - Buttery
  - Maltol - Toasty

Pyrolysis Temperatures

Fructose	110 °C
Dextrose	160 °C
Sucrose	160 °C
Maltose	180 °C

* Higher kiln temps increase of rate of formation of Caramelization Products, more Sugars are initiated in Pyrolysis

Maillard Reactions - Toasty, biscuit, burnt, Chocolate, buttery

3-10 % moisture

>140° C

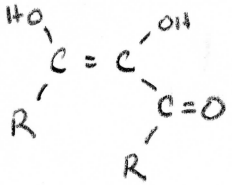
Sugar + Amino Acid → Products

Reductones - Antioxidants

Melanoidins - Pigments (Brown Hues)

Oxygen Heterocycles - Caramel-like flavours

Reductone



O-Heterocycle

Class Activity :

- Split grains to groups
- each group tries grain; Identify:
  - Malt procedure
  - Possible reactions
  - Flavors, texture, etc.
- Each group shares their critique, Pass all grains around

Malt Analysis Sheets

Extract Fine grind - max extract when barley is finely ground

Course grind - Coarsly ground

F/C Difference - Difference between fine/coarse extract

% mealy - % of lot of barley that is <25% steely (Hard)

→ mealy = soft = more extract

% Half - % of lot that is 25-75 % steely

% steely/glassy - % that is >75 % steely (steely = glassy = hard)

% protein - % of protein

Brewing Metrics

Specific Gravity - Hydrometer

* measurements taken @ reference temp, need to correct densities if sample not @ reference temp.

$$SG = \frac{\rho_{sample}}{\rho_{reference}}$$

$\rho_{reference} = \rho_{H_2O,\ 60°F}$ $\quad 60°F = 15.56°C$

↳ Ratio = unitless

$$\frac{\rho_{H_2O,\ 60°F}}{\rho_{H_2O,\ 60°F}} = 1$$

→ Solids dissolve → SG ↑

→ liquids less dense than reference → SG ↓

Brix (°B) and Plato (°P) - Refratometer

- Sugar content in solution

1°B = 1 gram of Sucrose in 100 grams of Solution

* 1°B ≈ 1°P → Can be used interchangably.

Sucrose chosen as reference for definition because Sucrose yields the highest increase in Specific gravity.

∴ if a sample has 10°B, it does not mean it has 10 grams of Sucrose per 100 grams of sample.

Conversion: SG ↔ °B/°P

$$S.G. = \frac{(°B \times 4)}{1000} + 1$$

or

$$\frac{(S.G. - 1)1000}{4} = °B$$

Estimating the Required Grain for a Brew

1) Extract C.G. → % of retrievable material

2) Brew house efficiency → % that brewing equipment/Procedure can extract of the E.C.G. Value

3) Brew house Yield → % of grain extract utilized

$$B.H.Y. = \left(\begin{matrix}\text{Brew House}\\ \text{efficiency}\end{matrix}\right)\left(\begin{matrix}\text{Coarse Grind}\\ \text{efficiency}\end{matrix}\right)\left(1 - \%\,\text{Moisture}\right)^{x}$$

x only if C.G.E. given "As-Is"

B.H.E. affected by: milling, pH, mash Temp, Sparge/Lauter Style

example

100 gallons

S.G. - 1.060 (final gravity, Pre fermentation)

$\eta_{B.H} = 0.90$

$\rho_{H_2O,\,60^\circ F} = 8.338$ lbs/gallon

Grain Bill

60% - 6 Row

40% - Caramel 60°L

$$100\ \text{gallons} \cdot 1.060 \cdot 8.338\ \frac{\text{lbs}}{\text{gallon}} = 883.8\ \text{lbs wort}$$

$$S.G. \rightarrow {}^\circ P: \frac{(1.060 - 1)}{4}(1000) = 15^\circ P = \frac{15\ \text{lbs extract}}{100\ \text{lbs wort}}$$

$$883.8\ \text{lbs wort} \cdot \frac{15\ \text{lbs extract}}{100\ \text{lbs wort}} = 132.6\ \text{lbs extract}$$

$$\frac{132.6\ \text{lbs extract}}{0.90\ \eta_{BH}} = 147.3\ \text{lbs extract}$$

6-Row → $\frac{(147.3)(0.6)}{0.765} = 115.5$ lbs

Caramel 60°L → $\frac{(147.3)(0.4)}{0.73} = 80.7$ lbs